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STORAGE ROTS OF SWEET POTATOES

J.A. Elliott

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MARTIN NELSON, Director,
Fayetteville, Arkansas.

STORAGE ROTS OF SWEET POTATOES

John A. Elliott.

No single crop in Arkansas offers greater possibilities for a rapid increase of food-stuff in the present emergency than does the sweet potato crop. But while this is one of the most easily produced, it is also one of the most perishable crops and offers many difficulties in storage. The increase in acreage and production of sweet potatoes in the last few years has been very marked. The 1910 crop amounted to 1,685,000 bushels, while the 1917 sweet potato crop of Arkansas was estimated to be 4,400,000 bushels.* Approximately one-half of the annual crop is held in storage in order to take advantage of the higher prices of winter and spring. Aside from the unavoidable shrinkage due to the evaporation of water in curing, very high losses often occur due to preventable rots and diseases, greatly reducing the profits of the holders and depriving the nation and the world of vitally needed food-stuff. Under ordinary conditions of storing in Arkansas this loss will not be less than 30% of the stored crop. Under proper conditions of storage this loss could have been reduced to 2 or 3%, which would be a saving of about 500,000 bushels, worth at wholesale prices up to March, 1918, $750,000.00. At prices prevalent about the middle of March, this loss amounted to more than a million dollars.

CAUSE OF ROTS.

All of the sweet potato rots and diseases are due to specific organisms, in the nature of molds, and without these organisms it would be impossible for the diseases to occur. On the other hand, *these molds depend on certain conditions for their ability to destroy the potatoes.* The problem of successful storage is one of making conditions as favorable as possible for the sweet potatoes while at the same time preventing the development of the disease causing organisms. Low temperature will prevent the development of dis-

* U. S. Bureau of Crop Estimates.

cases, but, unfortunately, sweet potatoes sour at a low temperature and at the temperature best adapted to sweet potato storage (55° Fahrenheit), all the disease organisms will grow. Another condition needed by these organisms is high humidity, that is, an abundance of moisture in the air. If the humidity can be kept below the needs of the disease organisms, the potatoes can be saved from decay. Visits to storage houses, and diseased potatoes sent in to the department of Plant Pathology from all parts of the state show all the common sweet potato rots to be prevalent in Arkansas.

COMMON STORAGE DISEASES.

Soft Rot and Ring Rot. These are different phases of the same disease and are usually the cause of from 80 to 90% of the losses in storage. (Plate I, Nos. 1 and 2.) They are due to the common bread mold (*Rhizopus nigricans*), which is present in the air everywhere. It cannot attack sound roots properly cured and stored. Bruising or chilling, or the presence of too much moisture in the air, are very favorable to this rot. Care in handling and curing the potatoes, and proper heating and ventilating of the houses will control the disease.

Black Rot. This is a field disease but it spreads rapidly in storage under favorable conditions. It is caused by a fungus known as *Sphaeronema fimbriatum.* The fungus lives in the field to a certain extent, but is mostly spread by bedding diseased roots, or using old infested seed beds. It may start at any point on the root, but in storage is often found spreading from a plow injury, pox scar, mouse gnawing, or other wound (Plate I, No. 3). On the outside the spot appears gray or nearly black. When the root is broken or cut open the spot is seen to extend slightly below the skin and is black and brittle. As such potatoes are unfit for food or seed, care should be taken to cull them out as the crop is harvested.

"Mummy or Charcoal" Rot. This is the second most important storage disease in Arkansas and probably caused nearly as heavy losses in the winter of 1917-18 as did soft rot. The disease is caused by a fungus known as *Sclerotia baticola,* which probably enters the roots at the broken stem end or through the bruised skin at time of harvest. On the outside of the root the disease may appear as merely a slightly sunken hard area where the skin has been scuffed. If the potato is cut it may show a black or dark

gray area extending to the center of the potato (Plate I, Nos. 4 and 5). The disease may destroy the whole root. Potatoes carefully handled, quickly cured, and properly stored will suffer little from this rot.

Wilt or Stem Rot. This is primarily a field disease, but if roots having this disease are stored they often decay with a dry rot, the whole interior of the potato becoming dry and brown. Great care should be exercised to keep from spreading this disease by bedding infected roots.

Other Minor Rots. Several other minor rots cause some losses in storage, but all together they probably do not cause 1% of the usual losses. All of these are controlled by the methods described below. *Soil Stain* (Plate I, No. 6), causes serious shrinkage of the potatoes affected.

HOW TO PREVENT THE LOSSES.

First: Use care in handling.

Second: Store in properly constructed houses and bins.

Third: Cure the potatoes by kiln drying.

Fourth: Regulate the temperature and humidity of the storage house.

Before the potatoes are dug the storage house should be thoroughly cleaned and dried out. A good coat of whitewash, bluestone solution, (2 pounds in 50 gallons of water), or formaldehyde, (1 pt. in 15 gallons of water), applied with a brush or a bucket spray pump to the interior of the building, is valuable as a disinfectant and adds to the cleanliness. The disinfectant should be thoroughly dry before storing the potatoes. Bucket spray-pumps may be secured through any good hardware company.

CARE IN HANDLING.

No matter how well stored the potatoes may be, they will not keep if they have been roughly handled at any time before reaching the bins. To keep well, a sweet potato should be as carefully handled as an apple. Clean cuts, such as plow injuries, if the potato is properly cured, are less apt to be the starting points of rots than are bruises due to rough handling. In many large well regulated

commercial storage houses, a potato that falls from a wagon, or to the floor, is not put into the bins, and farmers who are known to be careless in the handling of the crop are discriminated against by the buyers. In filling the bins the potatoes should be poured carefully from the baskets or crates, and never thrown or allowed to fall. Proper care in handling the crop will greatly reduce the losses in storage.

CONSTRUCTION OF HOUSES AND BINS.

Success in curing the potatoes and in maintaining the proper temperature and humidity during storage depends on the construction of the house and bins. The construction of the bins is of special importance. They should be small enough to ventilate the potatoes in the center, should be surrounded by an air space on all sides, and be of convenient depth for filling without danger of stepping on potatoes on the floor or having to throw potatoes to the back of the bin when it is nearly full.

The height of the bin will depend on the type of building, but for convenience in handling, a bin 6 feet high is preferable. It should be from 3 to 4 feet wide and 8 feet long, with a gate in the middle to separate the bin into two 4 foot compartments. This provision is to make easier the filling of the bins without bruising the potatoes. The bins are constructed of 1 by 4's spaced 1 inch apart on 2 by 4 studding. There should be a four-inch air-space underneath the bins and 6 inches or more between the bins and the walls (Figs. 1 and 3). Sweet potatoes should never be piled against a wall or on the floor. In a two-story house, the potatoes may be placed on the floor of the second story if the floor boards are spaced 1 inch apart to give ventilation from below, but this may be objectionable on account of dirt sifting down on the potatoes underneath.

In the onstruction of the house three things are essential: that it shall be dry, tight, and easily ventilated.

In Arkansas, many thousands of bushels of sweet potatoes are kept in cellars in lots of a few hunderd bushels by farmers who feel that they cannot afford a storage house for their small crops. At least a third of the potatoes stored in this manner rot. In a few seasons, at usual prices, the loss to a community

would easily pay for the construction of a community storage house, which would greatly reduce their loss. At present prices such a storage house might easily pay for itself in a single season. The size of the house will depend on the amount of potatoes it is desired to hold.

Each bin of the size given above, 4x6x8 feet will hold approximately 130 bushels. A bin 3x6x8 feet will hold about 95 bushels. A house large enough for four of the larger bins would hold 520 bushels; 8 bins, 1,040 bushels; 40 bins, 5,200 bushels. When remodeling a house for storage use, the size of the bins may be modified slightly to suit the space, care being taken to make the compartments small enough to give ventilation and prevent bruising. For a small house, one story is probably best, but for a large house, two or three stories will prove cheaper in construction and more easily heated and ventilated. Plans and lumber bills are given here of a 500 bushel and a 3,000 bushel house. Some storage men get very good results by storing sweet potatoes in one bushel slat crates. When these are carefully handled and stacked to permit proper ventilation, very little loss occurs.

KILN DRYING.

After the potatoes are dug, if possible, they should be dried in the sun for a few hours before storing. From the time they are put in storage until they are "cured" sweet potatoes lose about 10% of their weight in moisture. It is during this period of "curing" that rots are most apt to set in, so that the more slowly this process takes place the longer the potato is subject to the attacks of rots. To hasten this curing process kiln drying has come into general practice. From the time the potatoes are put in storage until they are cured they should be kept at a temperature of from 85° to 95° Fahrenheit, at the same time being supplied by a constantly changing current of dry air to carry off the moisture. The process is considered complete when the juice will not run when the potato is cut or broken, or when it begins to sprout. This takes from 10 to 15 days. One of the most serious objections to cellars for sweet potato storage is the impossibility of kiln drying the potatoes in them, or properly ventilating them.

REGULATING THE TEMPERATURE AND HUMIDITY.

A current of air has a very much greater drying effect than still air of the same or of considerably higher temperature. For this reason, ventilation is the most important factor in curing the potatoes and maintaining the proper humidity of storage houses. During the curing process a bushel of potatoes gives off about 6 pounds or nearly ¾ of a gallon of water. Thus, 500 bushels of potatoes would give off more than 350 gallons, or 1,000 bushels 700 gallons of water, which is enough to cover the floor of a 1,000 bushel storage house more than four inches deep. The necessity of getting rid of this water is very evident. Too much emphasis cannot be put on the need of rapidly changing the air during the curing process.

Cold air from outside should be led into the house under the stove, which should be supplied with a metal jacket to confine the incoming air. As the air passes between the stove and the metal jacket it is heated and dried, then as it passes through the house it quickly takes up moisture from the potatoes. Ventilators in the roof, or a power blower, should remove this warm moist air to make room for the dry air coming from the stove.

After the potatoes are cured, care should be taken to keep the temperature as near 55° as possible and to keep the humidity down to 60% or below. A cheap instrument (Fig. 10) occasionally adjusted to give correct readings, will do very well to indicate the amount of moisture in the air. Whenever this gets too high the house should be ventilated. A few thermometers should be kept in the building to indicate the temperature. Thousands of bushels of sweet potatoes were lost in the winter of 1917-18, due to chilling in storage.

A tight dry house kept at a constant temperature and well ventilated should give an almost perfect keep. Sweet potatoes kept in pits or cellars are bound to show a very high percentage of loss even under the most favorable conditions, and such storage places should not be used except for keeping a few potatoes for home use.

STORAGE HOUSE CONSTRUCTION.

As has already been stated, the essentials for a successful storage house are that it shall be dry, tight and easily ventilated.

Any plan or material which will produce a house filling these requirements is acceptable, but all these requirements must be met. The following plans are given to assist in the construction of successful houses.

CONSTRUCTION OF BINS.

Fig. 1 shows the construction of a bin 6x4x8 feet dimensions. Several bins may be constructed together over one base with the bottom slats running the short way of the bin. This permits the 2x4's on which the bins rest to be laid lengthwise of the bins and secures better ventilation underneath. The middle partition and the front of the bin should be made in sections about 1 foot wide that may be put in as the bin is filled (Figs. 1 and 4). Bins may be made more than eight feet long if they are divided into sections of not more than 4 feet.

CONSTRUCTION OF HOUSES.

The house should be placed on a foundation high enough to insure a dry floor and to make easy the loading and unloading of wagons. A continuous foundation wall or piers of concrete or stone 12 to 18 inches high may be used. If piers are used heavy wood sills 8 by 8 inches must be placed on these, running the length of the house, on which to rest the joists. If a continuous foundation wall is built, a lighter sill of 2 inch planks may take the place of the heavy sill. On top of the sills, place 2x12 joists spaced 2 feet on center, extending the width of the house. If the width of the house demands it, piers should support these joists in the middle. The floor should be built of rough 1x12 sheeting laid diagonally on the joists, a layer of building paper, and matched board flooring. (See Fig. 2.)

The walls are constructed of 2 by 4 studding spaced two feet on center, outside of which is a layer of 1 inch rough sheeting, nailed diagonally to brace the building, a layer of building paper, and on the outside a layer of weather boards. The inside of the walls may be lined with matched boards, or for greater warmth, may have a layer of rough sheeting boards with building paper and matched boards over them. Such construction will make a tight, easily heated house.

The roof is constructed of 2x4 or 2x6 rafters, depending on the width of the house, spaced two feet on center, lined on the lower side the same as the inside of the walls. On the upper side the rafters are covered with building paper covered with one inch rough sheeting on which are nailed shingles or other roofing material (Fig. 7).

In a two-story house the rafters of the second floor may be made of 2x8's, 10's or 12's, depending on the width of the house. These will be spaced 2 feet on center, nailed to the studding and also supported by the bins below. The flooring is of matched boards. The flooring in the middle aisle and also back of the bins is made in hinged sections that can be raised to permit a rapid circulation of air in kiln drying and ventilating (see Figs. 7 and 8).

Air should be let into the building through 12x12 vents under the stoves. These should be provided with caps or shutters that can be tightly closed. In the small house the roof ventilator should be a cupola 3 feet square with two sash windows about 18 by 24 inches, swung on center and opened and shut by cords. In a large house, the cupola should extend the length of the roof with sash windows on both sides, that may be opened and shut as needed. (See Figs. 3 and 4.)

Lumber List—Building 12 ft. x 18 ft.

Sills, 2 pieces .... 2"x8"x18'
Sills, 2 pieces .... 2"x8"x12'
Rafters, 19 pieces .... 2"x4"x15'
¼ pitch.
Studding, 19 pieces .... 2"x4"x16'
Plates, 2 pieces .... 18'
Plates, 2 pieces .... 12'
3¼ M. shingles or 3¼ squares roofing.
100 sq. ft. Bldg. paper.
Bins, 10 pieces .... 2"x4"x 7'
Bins, 5 pieces .... 2"x4"x 8'
1"x4"x196'
[illegible]
1"x1"x144'

Joists, 10 pieces .... 2"x10"x12'
Ceiling, 10 pieces .... 2"x 6"x12'
Flooring, rough .... 240'x1"x6"—S. 4 S
Flooring, finish ...... 240'x3¼" face, matched
Sheathing, sides .... 700' No. 1 Boxing
Siding .... 700' 6" Beveled Siding
Sheathing, roof .... 400' No. 1 Boxing
Gables, ventilators, headers, etc.,
8 pieces .... 2"x4"x16'
4 window frames .... 12"x24"x4' lights
4 Windows .... 12"x24"x4' lights
2 sash .... 18"x24" glass in ventilator.

Lumber List—Building 23 ft. x 30 ft.

Solid Walls.

Sills, ends, 4 pieces .... 2"x8"x12'
Sills, sides, 2 pieces .... 14'
Sills, sides, 2 pieces .... 16'
Center girder, 3 pieces .... 14'
Center girder, 3 pieces .... 16'

Bins, 56 pieces .... 2"x4"x7'
Bins, 28 pieces .... 2"x4"x8'
1"x4"x11808'
1"x2"x864'
1"x1"x864'

Joists, 1st floor .... 32 pieces .... 2"x12"x12'
[illegible] .... 16'
[illegible] .... 14'
Joists, ceiling .... 32 pieces .... 2"x 6"x12'
Rafters, 3rd pitch .... 32 pieces .... 16'
(If ½ pitch, 18')
Flooring, Rough .... 800' 1"x6"—S. 4 S.
Flooring finish .... 1600' 3¼", Face Matched
Studding .... 60 pieces .... 2"x4"x16'
Plates .... 4 pieces .... 2"x4"x12'
[illegible]
[illegible]
Sheathing, sides .... 2300' 31 Boxing
[illegible] .... 2300'x6" Beveled Siding
Sheathing, roof .... 1200' No. 1 Boxing
10M Shingles, or 10 squares Roofing.
3500 sq. ft. Building Paper.
[illegible]
100 ft. flooring.

For Gables—Cupola.

[illegible]
16 Window Frames .... 12"x24"—4 lights
[illegible]
[illegible]

Explanation of Plate 1.

No. 1. Soft rotting sweet potatoes showing tufts of the mold (*Rhizopus nigricans*).

No. 2. *Soft rot* "mummy."

No. 3. *Black rot* extending from a "pox" scar.

No. 4. *Charcoal rot* "mummy."

No. 5. Cross section of a charcoal rotted sweet potato.

No. 6. Sweet potato showing *Soil Stain*.

Nos. 1, 2, 3, and 6, from photographs by Delaware Experiment Station; 4 and 5 original.

ACKNOWLEDGMENT.

The author is indebted to Professor T. F. Manns of the Delaware Experiment Station for some of the photographs used and for permission to use data collected while at Delaware Station; also to Mr. Dinwiddie of the College of Engineering, University of Arkansas, for the lumber lists.

PLATE I.

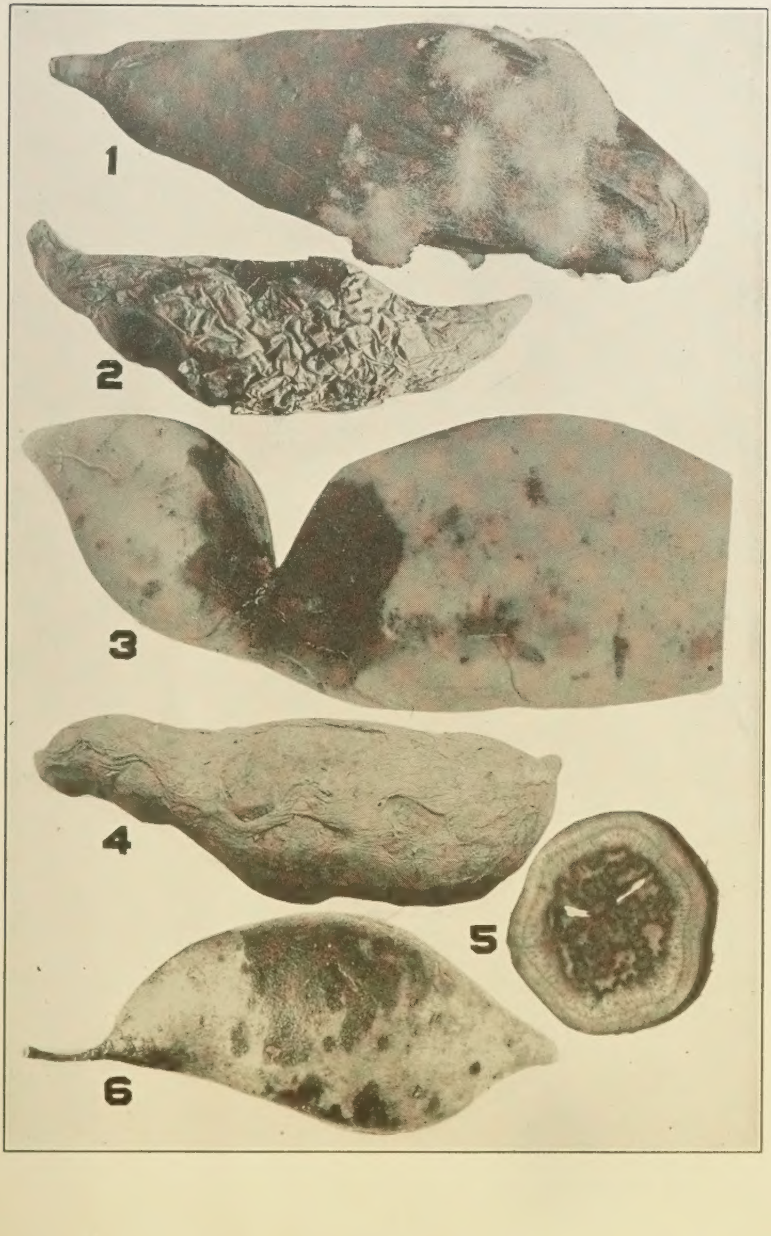

Plate II.

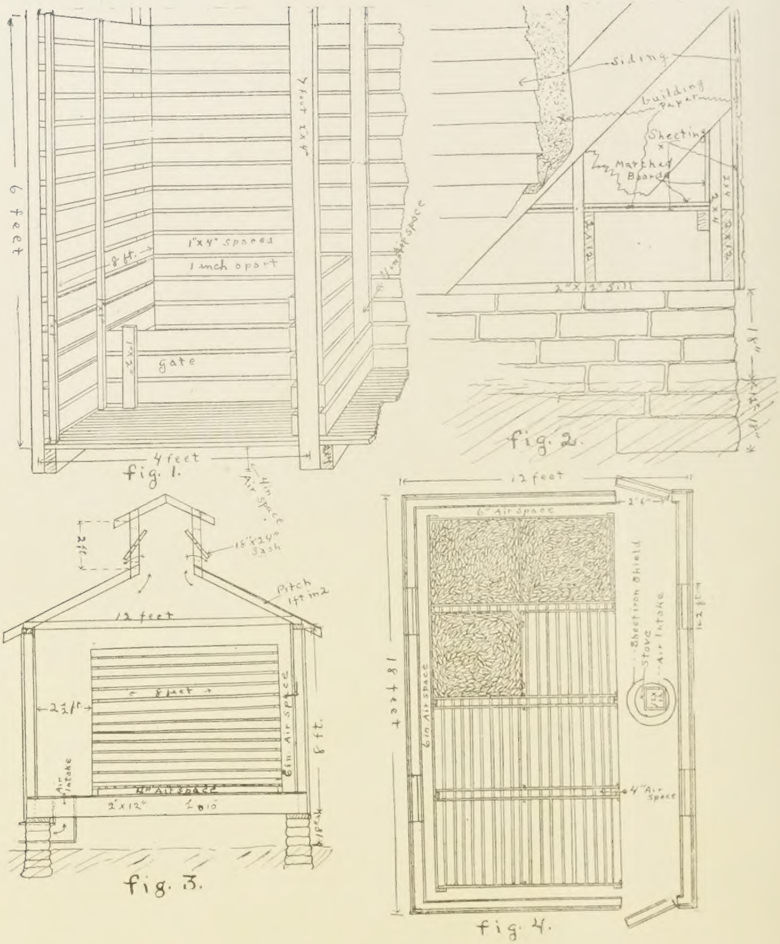

Fig. 1. Construction of bin.
" 2. Detail of wall and floor construction.
" 3. Cross section of 500 bu. house.
" 4. Floor plan of 500 bu. house.

PLATE III.

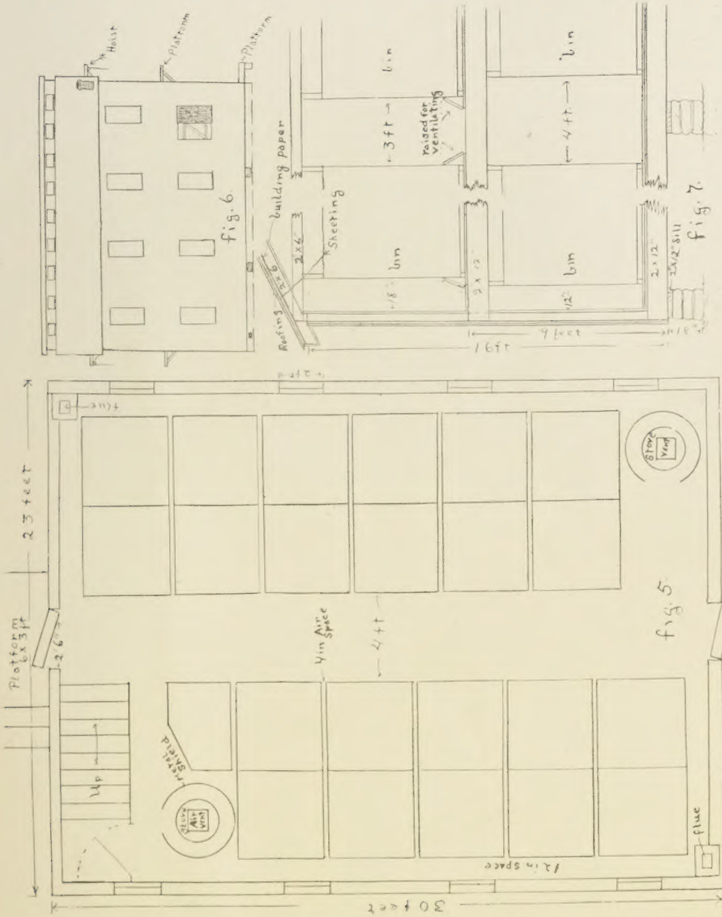

Fig. 5. 1st floor plan, 3000 bu. house.
" 6. Side view, 3000 bu. house.
" 7. Section of 3000 bu. house.

PLATE IV.

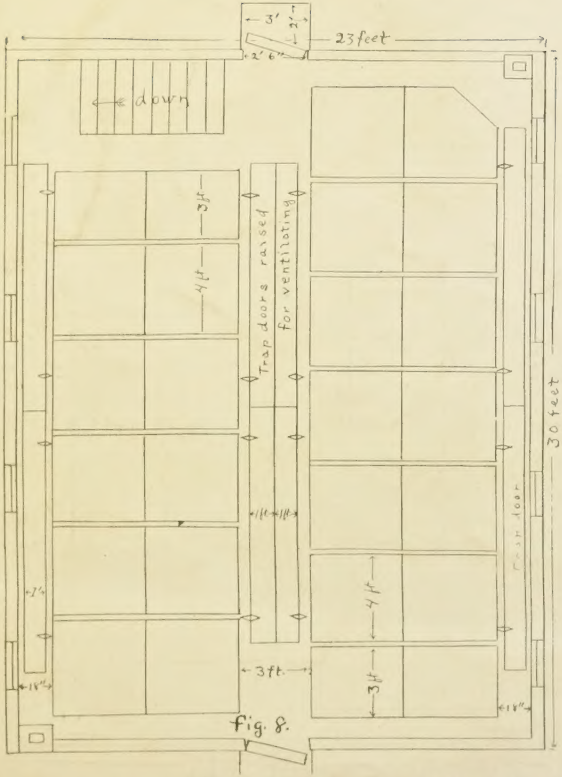

fig. 8.

fig. 10.

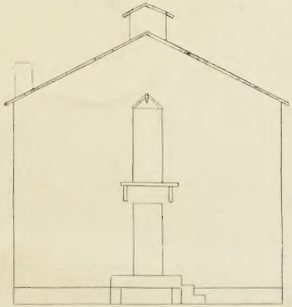

fig. 9. End Elevation

Fig. 8. 2nd floor plan, 3000 bu. house.
" 9. End view, 3000 bu. house.
" 10. Instrument for indicating humidity.